International Journal of Research and Applications (July - Sep © 2014 Transactions) 1(3): 80-83
International Conference on Emerging Trends in Engineering & Technology (ICETET-2014)
ISSN (online): 2349-0020
ELECTRONICS ORIGINAL ARTICLE

A Robust Channel Estimation for SCFDMA System

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ABSTRACT

In this paper, a robust technique is proposed for a single carrier frequency division multiple access system channel estimation in flat- fading non- Gaussian channels. Further, A new M-estimator is proposed for the robustification of the proposed detector. Simulation results are also provided to demonstrate the efficacy of the proposed detector over the least squares, Huber and Hampel based detectors in flat- fading non- Gaussian channels.

Keywords: Channel estimation, Fading channels, M-estimator, SC-FDMA.

I. INTRODUCTION

I. INTRODUCTION

Wide demand on high data rates in wireless communication systems has arisen in order to support broadband services. The Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) radio access standard provides peak data rates of 75 Mb/s on the uplink and 300 Mb/s on the downlink. In LTE standard orthogonal frequency-division multiple accesses (OFDMA) is used on the downlink. This supports different carrier bandwidths (1.25–20 MHz) in both frequency-division duplex (FDD) and time-division duplex (TDD) modes. In OFDMA each user is provided with a unique fraction of the system bandwidth. OFDMA combines scalability, multipath robustness, multiple-input multiple-output (MIMO) compatibility [1], thereby making it adaptive for wideband wireless accessibility.

OFDMA, being sensitive to frequency offset and phase noise, accurate frequency and phase synchronization is needed. In addition, OFDMA is characterized by a high transmit PAPR, and for a given peak power limited amplifier this results in a lower mean transmit level. For these reasons, OFDMA is not well suited to the uplink transmission. Hence, LTE proposed, single carrier FDMA (SC-FDMA), also known as discrete Fourier Transform (DFT) pre coded OFDMA, for the uplink. PAPR reduction in SCFDMA is motivated by a desire to increase the mean transmit power, improve the power amplifier efficiency, increase the data rate, and reduce the bit error rate (BER) and energy consumption [4]. SC-FDMA ensures high data rate transmission, utilizing single carrier m frequency domain equalization. In algorithm is proposed for LTE uplink channel impulse response (CIR) knowledge of the channel.

II. CHANNEL MODEL

At the transmitter side, a baseband modulator transmits the binary input to a multilevel sequences of complex numbers m1(q) in one of several possible modulation formats including binary phase shift keying (BPSK), quaternary PSK (QPSK), 8 level PSK (8-PSK), 16-QAM, and 64-QAM. These modulated symbols perform an N-point discrete Fourier transform (DFT) to produce a frequency domain representation. The DFT followed by IDFT in a distribution-FDMA (DFDMA) or localization-FDMA (LFDMA) subcarrier mapping setup operates as efficient implementation to an interpolation filter. In

distributed subcarrier mode, the outputs are allocated equally spaced subcarriers, with zeros occupying the unused subcarrier in between. While in localized subcarrier mode, the outputs are confined to a continuous spectrum of subcarriers. Except the above two modes, interleaved subcarrier mapping mode of FDMA (IFDMA) is another special subcarrier mapping mode [12], [13]. The difference between DFDMA and IFDMA is that the outputs of IFDMA are allocated over the entire bandwidth, whereas the DFDMA's outputs are allocated every several subcarriers. The response of the wide-sense stationary uncorrelated scattering (WSSUS) fading channel can be represented as

$$w(\tau,t) = \sum_{j=0}^{l-1} w_j(t)\delta(\tau-\tau_j) \quad (1)$$

where fading channel coefficients $w_j(t)$ are the wide sense stationary i.e. $w_j(t)$ = w(m; j), uncorrelated complex Gaussian random paths gains at time instant t with their respective delays τ_j, where w(m; j) is the sample spaced channel response of the l[th] path during the time k, and $\delta(\bullet)$ is the Dirac delta function. Based on the WSSUS assumption, the fading channel coefficients in different delay taps are statistically independent. And has an autocorrelation function given by

$$E\left[w(k,j)w^T(n,j)\right] = \sigma_w{}^2(j) J_0\left(2\pi f_d T_f (k-n)\right) \quad (2)$$

Where w (n; j) is a response of the l[th] propagation path measured at time n, $\sigma_w^2(J)$ denotes the power of the channel coefficients, f_d is the Doppler frequency in Hz, T_f is the symbol duration in seconds, and $J_0(\bullet)$ is the zero order Bessel function of the first kind(4).

III. PROPOSED ALGORITHM

The signal s (k) is transmitted via a time-varying channel w (k), and corrupted by an observation noise n (m) before being detected in a receiver. The signal received at time index k is

$$\begin{aligned} r(k) &= s_1(k-1)w_1(m) + \ldots \quad \ldots + s_l(k-l)w_l(k) + n(k) \\ &= \sum_{j=1}^{l} s_j(k-j)w_j + n(k) \\ &= S^T(k)W(k) + n(k) \end{aligned}$$

Where $s_j(k-j)$, $j = 1,2,\ldots,l$ are transmitted signal vectors at time m, l is the distinct paths from transmitter to the receiver, w(m) is the channel coefficients at time m, and n(k) is the noise with zero mean and variance σ^2 . After processing some intermediate steps (synchronization, remove CP, DFT, and de mapping), the decision block reconstructs the detected signal to an approximate modulated signal and its phase. The output y(k) of the adaptive filter is expressed as

$$\begin{aligned} y(k) &= d_1(k-1)h_1(k) + \ldots \quad \ldots + d_l(k-l)h_l(m) \\ &= \sum_{j=1}^{l} d_j(k-j)h_j(k) \\ &= D^T(k)h(k) \end{aligned}$$

Where $d_j(k-j)$, $j = 1,2,\ldots,l$ are detected signal vectors at time $k \ldots D(k) = diag\left[d_1(k-1), d_2(k-2), \ldots, d_l(k-l)\right]$ In this problem formulation, the ideal adaptation procedure would adjust $w_j(k)$ such that $w_j(k)=h_j(k)$as $k \to \infty$. In practice, the adaptive filter can only adjust w(k) such that y(k) closely approximates desired signal over time. There- fore, the instantaneous estimated error signal needed to up- date the weights of the adaptive filter is

$$\begin{aligned} j(k) &= p(k)e^T(k)e(k) \\ e(k) &= r(k) - y(k) \\ &= r(k) - D^T(k)h(k) \end{aligned}$$

This priori error signal, e(k) is used to minimize the estimator error by adaptive updating of filter weights. $w(i) = [w_0(i), \ldots. w_{N-1}(i)]^T$ is the channel noise vector during the i[th] symbol interval. w(i) are assumed to be independent and identically distributed random variables with non- Gaussian distribution.[ ]

$$(1-\varepsilon) f(0,\sigma_1^2)+\varepsilon f(0,\sigma_2^2) \quad (12)$$

Several different classes of robust methods (such as M, L, R estimators, and the least median of squares method) exist [7-9]. In this paper, M-estimator based robust clustering technique is proposed. The M-estimators try to reduce the effect of outliers by replacing the squared residuals r_i^2 by less rapidly increasing function ρ of the residuals, yielding

$$\min_{c} \sum_{i=1}^{N} \rho(r_i) \quad (3)$$

Where ρ is a symmetric, positive-definite function with a unique minimum at zero, and is chosen to is less increasing than squared function? Let $C=[c_1,.....c_k]$ be the parameter vector to be estimated. The M-estimator of c based on the function $\rho(r_i)$ is the vector **C** which is the solution of the following k equations:

$$\sum_{i} \psi(r_i)\frac{\partial r_i}{\partial c_j}, \ for\ i=1,...,k \quad (4)$$

where the derivative $\psi(x)=\dfrac{d\rho(x)}{dx}$ is called the

influence function. The influence function $\psi(x)$ measures the influence of a datum on the value of the parameter estimate. In this paper, a new M-estimator is proposed for robustifying the k-means clustering algorithm. The penalty function and the influence functions of the proposed M-estimator are given by [10] (also see Fig 1).

$$\rho_{PROPOSED}(x)=\begin{cases} \dfrac{x^2}{2}, for & |x|\le a \\ \dfrac{ab}{2}-a|x|, for & a<|x|\le b \\ -\dfrac{ab}{2}\exp\left(1-\dfrac{x^2}{b^2}\right)+d, for & |x|>b \end{cases} \quad (5)$$

where d is any constant.

$$\psi_{PROPOSED}(x)=\begin{cases} x, for & |x|\le a \\ a\,\mathrm{sgn}(x), for & a<|x|\le b \\ \dfrac{a}{b}x\exp\left(1-\dfrac{x^2}{b^2}\right), for & |x|>b \end{cases} \quad (6)$$

The choice of the constants a $=kv^2$ and b $=2kv^2$ depends on the robustness measures derived from the influence function.

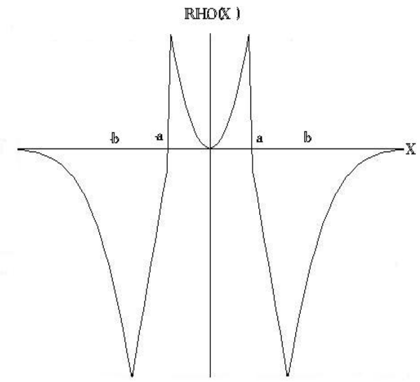

Fig. 1(a)

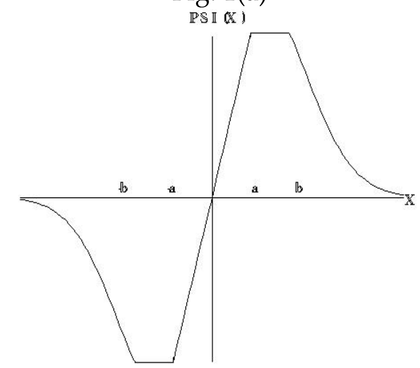

Fig.1 (b)

Fig. 1 (a) Penalty functions and (b) influence functions of the Proposed M-estimator.

IV. SIMULATION RESULTS

The performance of the proposed algorithm is compared with the Least Squares, Huber and Hampel based detectors in a Rayleigh fading environment and corrupted with non-Gaussian noise. The simulation parameters are listed in table1. The BER is a significant performance parameter for quality measurement recovered data in wireless communication effect of the proposed algorithm in terms of BER compared with existing estimators. It is

evident from these results that the proposed algorithm outperforms the Least Squares, Huber and Hampel based detectors in non-gaussian environment.

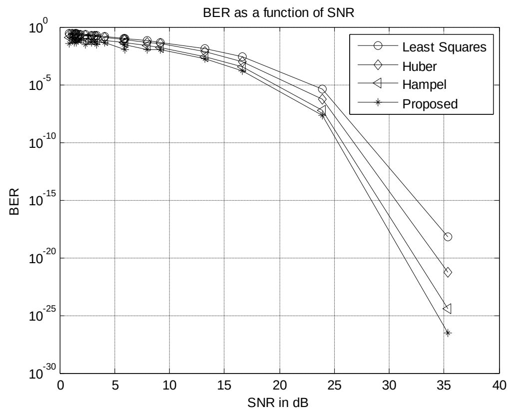

Fig. 2 Probability of error versus SNR for the considered detectors in Gaussian noise.

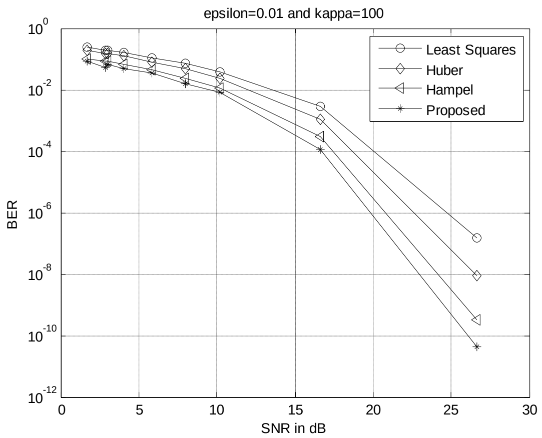

Fig. 3 Probability of error versus SNR for the considered detectors in non-Gaussian noise.

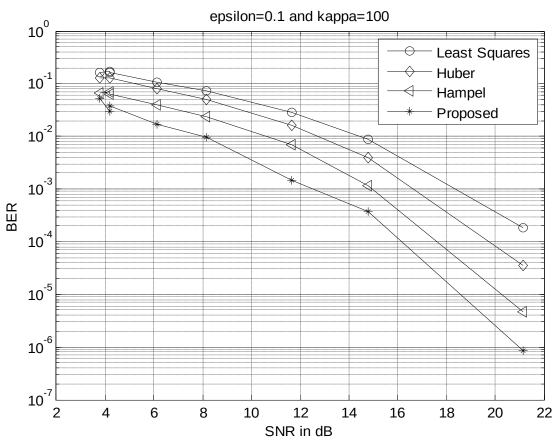

Fig. 4 Probability of error versus SNR for the considered detectors in non-Gaussian noise.

V. CONCLUSIONS

In this paper, a robust detection technique is proposed to estimate channel parameters when the signal is corrupted with non-Gaussian noise. A new M-estimator is proposed. Simulation results are also provided. These simulation results prove that the proposed detector outperforms Least Squares, Huber and Hampel based detectors in non-Gaussian flat-Fading channels.

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